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NOISE AND SONIC BOOM IMPACT TECHNOLOGY

Initial Development of an Assessment System for Aircraft Noise (ASAN): Executive Summary

Volume I of IV Volumes

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This is the first volume of a four volume report describing the development of a preliminary prototype version of an Assessment System for Aircraft Noise (ASAN). ASAN is a software system intended to assist members of the United States Air Force environmental planning community to comply with noise-related aspects of the environment impact assessment process required by the National Environmental Policy Act (NEPA) of 1969 and other regulations.

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Executive Summary

This is the first volume of a four volume report describing the development of a preliminary prototype version of an Assessment System for Aircraft Noise (ASAN). ASAN is a computer software system intended to assist members of the Air Force environmental planning community to comply with noise-related aspects of the environmental impact assessment process required by the National Environmental Policy Act of 1969 (NEPA, 1969) and other regulations.

Volume II of this report contains a more detailed account of the development strategy and capabilities of the preliminary prototype version of ASAN, and recommends actions needed to develop a final prototype version. Volumes III and IV contain technical appendices and listings of the source code for the preliminary prototype version of ASAN.

Foreword

This report was prepared under Contract F33615-86-C-0530 of the Noise and Sonic Boom Impact Technology (NSBIT) Program. The NSBIT program is conducted by the United States Air Force Systems Command, Human Systems Division (HSD/YA) under the direction of Capt. Robert Kull, Program Manager. Mr. Lawrence Finegold was the Technical Monitor for this effort. The wording and organization of the current version of this report reflect ADPO comments on an earlier draft.

Submission of this report concludes the effort required under Task Order 0003 of the NSBIT Contract, which started on 12 February 1987.

1. INTRODUCTION

The United States Air Force (USAF) environmental planners must often prepare impact assessment documents that predict and analyze noise effects associated with aircraft operations. Planners have at their disposal a well-developed set of computerized tools and Air Installation Compatible Use Zone (AICUZ) procedures for accomplishing noise-related analyses in airbase environs. However, they currently have no comprehensive means for evaluating noise effects associated with the very different sorts of exposure near Military Training Routes (MTRs) and Military Operating Areas (MOAs) that are of concern to the Noise and Sonic Impact Technology (NSBIT) program.

As a result, those who must predict effects of intermittent exposure to sonic booms and unexpected low altitude, high speed flyovers on people, animals, and structures encounter numerous technical and practical difficulties. These technical difficulties, which NSBIT seeks to rectify, include:

- inadequate and unstandardized quantitative models for predicting various noise effects.
- incomplete scientific understanding of potential effects of unexpected, intermittent noise exposure on people, animals, and structures;
- inadequate means for interpreting a large, complex, and inconsistent technical literature; and

The practical difficulties include:

- minimal training and relatively rapid turnover of personnel experienced in environmental acoustics;
- problems of obtaining, storing, retrieving, manipulating, updating, examining, modifying, comparing, and combining graphic materials such as maps, charts, graphs, aerial photography, and satellite imagery, of different scales and projections, and from different sources;
- similar problems in handling voluminous textual and tabular information in documents of many types from many sources;
- poor access to historical data and reference material concerning aircraft operations, noise exposure, land use, population distributions, and related matters;
- non-systematic access to current sources of information and points of contact for parties interested in particular environmental impact assessments;
- production of complex environmental analysis documents combining large amounts of textual, tabular and graphic information; and

- problems in exercising computationally complex models of aircraft noise emissions, acoustic propagation, structural damage, point and area exposure estimates, and so forth.

Among the consequences of this lack of systematic and comprehensive tools for analyzing noise effects have been:

- long delays in the production of environmental impact assessment documents for MTRs and MOAs;
- creation of marginal environmental impact assessment documents that invite challenge and further delay;
- considerable expense in both the production and defense of USAF environmental assessments; and (in some cases),
- compromises in training effectiveness related to delays and reductions in airspace utilization.

This report describes the development of a preliminary prototype version of a computer-based Assessment System for Aircraft Noise (ASAN) for the use of members of the USAF environmental planning community in conducting the noise-related portions of environmental impact assessments for MOAs and MTRs. The product of this initial development was a system intended as a proof-of-concept demonstration. Demonstrations of working software and hardware were made to the NSBIT ADPO at Wright-Patterson Air Force Base, OH on 18 February 1988, and on subsequent occasions such as the 28 April 1988 meeting of the North Atlantic Treaty Organization (NATO) Committee on the Challenges of Modern Society (CCMS) in Williamsburg, VA.

2. RATIONALE FOR DEVELOPMENT OF ASAN

The rationale for development of ASAN as well as preliminary and detailed system specifications are described in Volume II of this report, and also by Fidell and Harris (1987), Harris and Fidell (1987), and Fidell, Harris and Reddingius (1988). The following sections of this chapter summarize this information.

2.1 System Design Decisions

The primary user for whom ASAN is intended is a USAF officer or civilian serving in a major command or environmental planning office. This end user is assumed to have few computing skills, limited access to a computer larger than a desktop machine, and only a basic understanding of environmental acoustics. Although ASAN contains a number of features which may be exploited by more sophisticated users, the general mode of operation of the software is designed for inexperienced users.

Effort during the first half of the program concentrated on system definition. The statement of work for this effort assigned to the contractor the responsibility for analyzing the needs of USAF environmental planners, and for recommending and then designing a computer based system that could provide tools needed to improve the ability of environmental planners to comply with the noise-related aspects of NEPA. The decisions made during the first 6 months of the project are described in the following subsection.

2.2 Implementation Decisions

2.2.1 Hardware

The initial prototype version of ASAN was developed for the Zenith Z-248 personal computer under the MS-DOS operating system. (The choice of host computer on which ASAN is to be made available to end users is to be reviewed at least twice more in the course of ASAN development due to the rapid rate of progress in personal computer technology.) The reasons for this selection were:

- These machines are of simple, reliable and proven design, and have been purchased in large quantities by the USAF. Since they are already part of the USAF inventory,

they are likely to be available to individual environmental planners at the base level without special procurement efforts. Furthermore, since the machines and their MS-DOS operating systems are in common use in the USAF management, training and documentation problems are small with respect to those that would attend selection of a different computing environment.

- They are sufficiently fast and powerful to support the required tasks locally, in a stand-alone environment, without extensive interaction with centralized facilities.
- They provide compatible upgrade paths from the Intel 80286 to the Intel 80386 processor, and from the present single-user, single-task operating system to concurrent (background/foreground) operating systems expected to be available at the time of the first release of a production version of ASAN. These hardware and software upgrade paths minimize the effort required to accommodate future advances in personal computer technology which the USAF is likely to adopt by the time ASAN is ready for distribution.
- They are already the host computers for much of the existing (commercially available and previously developed) software to be incorporated into ASAN.
- They represent a significant market force, so that many applications programs, including a number developed under USAF sponsorship, are available in compatible versions.
- The additional peripheral hardware necessary to support ASAN is available relatively inexpensively to fit the machines' standardized electronic connection bus.
- The installed base of this and other IBM PC/AT compatible computers, both within the armed services and in the commercial arena is very large, assuring that their components and design philosophy will be supported well into the future.

The minimal hardware suite required for operation of the preliminary prototype version of ASAN was a Zenith-248 computer equipped with a color console monitor, commercially available add-in memory and a display controller, and a separate high resolution, large screen color monitor for map display.

2.2.2 Software Architecture

Even though the major goal of developing a preliminary prototype version of ASAN was to support a proof-of-concept demonstration, an important secondary goal was to minimize creation of "throw-away" code that could not be reused in subsequent phases of ASAN development. The decision was therefore made to modularize ASAN software to the greatest extent practical, thereby preserving independence of control logic, application code, and data.

It was also decided that all high level code in ASAN would be written in the C language to take advantage of the efficiencies of structured programming techniques, software libraries, compilation aids, and other modern software development tools. Writing in C language was also

expected to facilitate eventual transportation of the code developed for the preliminary and final prototype versions of ASAN to the host computers and operating environments available for the distribution of ASAN in 1992 and thereafter.

Fundamental architectural decisions (notably identification of the main software building blocks) were required very early in the development cycle. As shown in Figure 2-1, these major building blocks included the user interface and the text and graphics database management packages.

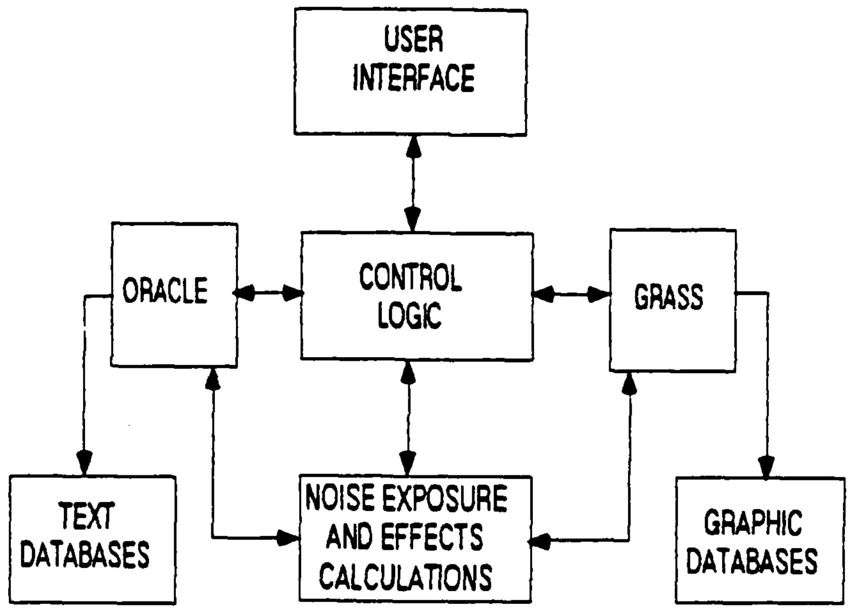

Figure 2-1: Major Building Blocks of ASAN Software.

User Interface

From the user's perspective, the look and feel of ASAN are determined by the user interface, since the interface shields the user from the complexities of the underlying software. An existing screen-oriented interactive interface was selected for ASAN. The principal criteria for selection of the user interface were ease of use for inexperienced end users, facilitation of code development through isolation of execution logic from input/output logic, and the ready availability and low cost of the interface.

Relational Database Management

The second major building block on which ASAN was developed was a relational database

management system. A relational database management system can be used to completely decouple an application program from the physical organization of the data on which it operates. This design makes it possible for data stored in one place to be accessible to all application programs, while greatly simplifying the maintenance (updating, error correction, modification) of the data. Use of a relational database management system on a properly designed database also makes it possible to perform *ad hoc* (i.e., unanticipated) queries with relative ease. These capabilities are essential for information retrieval and decision support systems such as ASAN that must function in a relatively unstructured work environment.

ASAN insulates the end user from direct creation and manipulation of most of the databases on which it operates. This design reduces needs for training and computational skills, while encouraging concentration of effort on generation of work products. This design goal was implemented in the preliminary prototype version of ASAN by interposing a layer of control software between the database management software and the user. More sophisticated users of ASAN may nonetheless directly access the ASAN database through the database manager's implementation of the Structured Query Language (SQL).

The primary criteria for selecting database management software for incorporation into ASAN were:

- availability of a version that could execute in IBM PC/AT MS-DOS and Zenith DOS operating environments;
- ability to rapidly and efficiently locate records;
- ability to accommodate variable length records;
- minimal consumption of system resources such as volatile and mass storage;
- absence of gratuitous capability, especially that which increased size or decreased performance;
- ability to operate while co-resident in main memory with other software, taking advantage of remaining memory;
- imposition of minimal constraints such as arbitrary limits on number of bytes in a field, number of fields in a record, or number of records in a database; and
- implementation of all capabilities as a library of functions callable from external C language programs.

Geodatabase Management

The geodatabase management system selected as the basis for the ASAN geodata software was a public domain software package written in the C language at the U.S. Army Construction

Engineering Research Laboratory. Version 2.0 of this Geographical Resources Analysis Support System (GRASS) was released shortly before development of ASAN began.[1]

GRASS is a grid cell (raster) based system capable of rapid production of extensive map comparisons and overlays. It was designed from the outset as a modern interactive system, and performs its operations somewhat faster than other geoinformation systems. It accepts digital geodata in a variety of formats, and can resample the original data to change scales.

GRASS was preferred to other geodatabase systems for the following reasons (among others):

- GRASS geodata formats are reasonable, well-defined, very efficient, and proven in actual use. The GRASS can store data in compressed forms to reduce mass storage requirements for geodatabases.
- GRASS produces well composed and formatted graphic output, in color, on a variety of display and hardcopy devices. Its graphic output functionality is highly modular, and is largely independent of actual output devices. Output devices can easily be rearranged and substituted, and graphic output commands can be redirected to mass storage for later printing or display.
- GRASS is structured as a library of independent subprograms, so that unnecessary functionality can be easily omitted.
- The original software development group is intact and actively working on enhancements to the system. Code development is proceeding in a systematic and rigorous fashion, in a modern development environment. A single agency, the U.S. Army Construction Engineering Research Laboratory (CERL), has complete authority and responsibility for the development of GRASS, and is providing excellent documentation and support for the package.
- Source code for GRASS is available for the minimal cost of copying and distribution.

2.2.3 Database Development

The objective of database development for the preliminary prototype version of ASAN was to provide a basis for demonstrations of future ASAN capabilities. An extensive graphics database and three text databases were developed to satisfy this objective.

[1]Version 3.0 of GRASS was released shortly after completion of the initial development work described in this report.

Graphics Database

The geographic area of the Sells MOA in Arizona was selected to demonstrate the capability of ASAN for manipulating graphic databases. Map layers were created by digitizing U.S. Geological Survey and other maps into formats suitable for display in ASAN. Other map files were created directly from digital data obtained from other sources (e.g., digital elevation model data prepared by the U.S. Geological Survey) to produce the sets of map layers described below.

Maps were digitized at coarse, intermediate, and fine scales. The coarse resolution map covered a rectangular area of about 10,000 square miles encompassing the complete Sells airspace. The coordinates of the vertices of the maps digitized to a coarse scale (counterclockwise from the southwestern corner) are shown in Table 2-1.

Intermediate resolution maps were produced for a rectangular area of 469 square miles that encompassed a completely contained piece of terrain surrounding the town of Sells. A secondary area which was not contained within the coarse scale map area was also digitized at this scale in the vicinity of the town of Ajo.

Fine resolution maps were created for an area of 19 square miles showing a completely contained piece of terrain surrounding the town of Sells. A secondary area which was not contained within the coarse resolution map was also digitized at this scale in the vicinity of the town of Ajo.

Table 2-1: Location of ASAN Demonstration Area

Sells Area Coarse Scale Map	
VERTEX	LAT/LONG
Southwest	31 degrees 34 minutes / 113 degrees 22 minutes
Southeast	31 degrees 34 minutes / 111 degrees 38 minutes
Northeast	32 degrees 59 minutes / 111 degrees 38 minutes
Northwest	32 degrees 59 minutes / 113 degrees 22 minutes

The three primary maps (i.e., the coarse, intermediate and fine scale maps of the area surrounding the town of Sells) were fully nested to display software zoom capability. The intermediate resolution maps for the town of Ajo did not overlap the fine resolution Sells area.

A total of 93 map layers was produced for display and manipulation of graphic data at the various scales. These layers included boundary outlines for MOA and other political entities (National Park, Indian Reservation, County, Census Tract and legislative districts); lineal

features such as streams and rail, highway, and MTR routes; aircraft noise exposure contours; structural features; place names; areal extents of human land uses and animal habitats; and so forth. ASAN can also display and manipulate any other digital line graph or grid cell maps that conform to GRASS conventions.

Citation Database

A citation database was developed to demonstrate how ASAN could assist users in compilation and evaluation of the technical literature on the effects of sonic boom and subsonic aircraft noise on health, animal populations, and structures. The database also includes modeling and aircraft noise citations associated with prediction of exposure to subsonic and supersonic aircraft noise.

The information provided for each citation in the database varies with the relevance of the publication to the environmental impact assessment process. Figure 2-2 shows the three levels of information provided. Table 2-2 shows the numbers of entries in each area.

BASIC INFORMATION

- AUTHOR
- TITLE
- PUBLICATION NAME
- DATE
- SUITABILITY RATING

COMPLETE INFORMATION

- ABSTRACT
- KEYWORDS
- CONTROVERSIALITY RATING

CRITICAL REVIEW

Figure 2-2: Levels of Information Provided for Citations.

Table 2-2: Numbers of Entries in Citation Databases

Citation Database Entries	
Effect Category	*# of Entries*
Human effects	630
Animal effects	621
Structural effects	448

The total number of citations contained in the preliminary prototype version of ASAN was 1,699. About a third of these citations contained complete information. Only a few citations went through the critical review process.

Point-of-Contact Database

The point-of-contact database contains names, addresses and telephone numbers of individuals and organizations useful to environmental planners in collecting site specific data. The database contains both national and local contacts associated with the Sells MOA demonstration site.

Legislative Database

The legislative database will contain a collection of national, state, and local laws and regulations governing the preparation, content and criteria for environmental assessment. No applicable Arizona regulations governing allowable noise exposure of humans, animals or structures were found for the Sells demonstration site.

3. DESCRIPTION OF PRELIMINARY PROTOTYPE VERSION OF ASAN

Figure 3-1 shows the functional capabilities of the preliminary prototype version of ASAN from the user's perspective. These capabilities are accessed by selection of actions displayed on various screens. For example, Figure 3-2 shows the actions accessible from the main screen for defining an environmental assessment. From this screen, users may choose to work with (that is, add or delete information, rescale, composite, print, etc.) map information, or to specify aircraft types and missions for MTRs and MOAs.

About thirty such screens were prepared for the preliminary prototype version of ASAN. The appearance of most of these screens is altered by user actions, as pop-up windows are provided as required to permit input or display of information relevant to the user's commands.

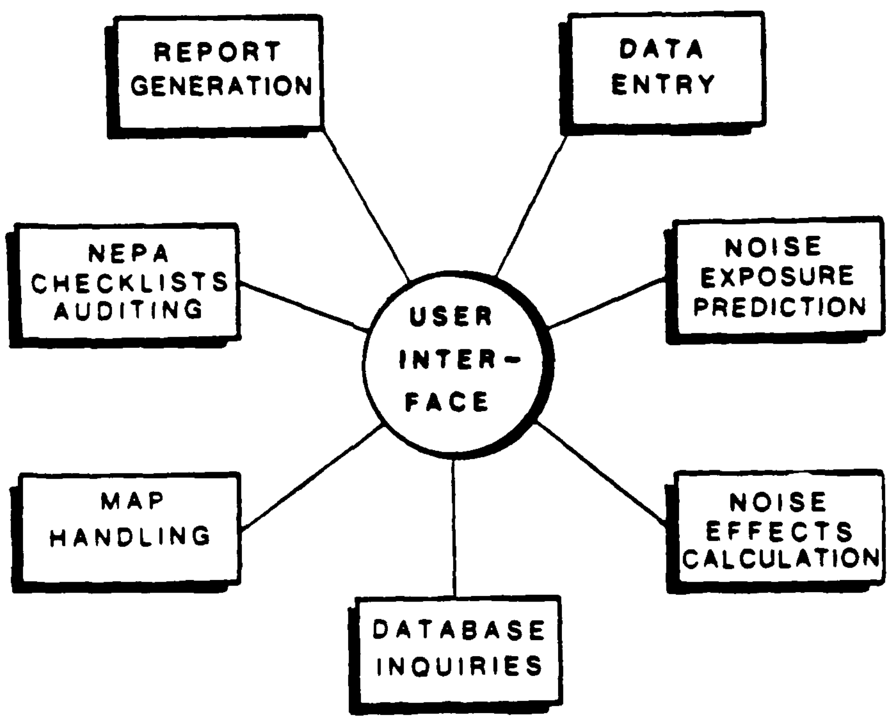

Figure 3-1: ASAN Capabilities from User's Perspective.

ENVIRONMENTAL ASSESSMENT DEFINITION

Name of current assessment: DEMONSTRATION
Comment: Sample environmental assessment for NSBIT Meeting 2/18/88

Actions you can now take to add information to this assessment:

◆ Work with map information (designate land uses, update maps)

◆ Work with MTR information (number or type of aircraft, missions, etc.)

◆ Work with MOA information (number or type of aircraft, missions, etc.)

Alternative actions you can now take:

◆ Analyze data ◆ Review assessment status
◆ View checklist for current assessment ◆ Make a report

> = fwd, < = bkwd, <enter> = do it, ? = help, ^C = quit

Figure 3-2: Appearance of Environmental Assessment Definition Screen.

4. CURRENT PLANS FOR ASAN DEVELOPMENT

It is anticipated that development of the preliminary prototype will be followed by development of a final prototype, then by a period of trial use and evaluation, and finally by production of a formally released version of the ASAN software.

4.1 Functional Prototype

The preliminary ASAN prototype demonstrated the system concept but has little operational capability. The alpha-test requires a prototype which fills out the functional skeleton of ASAN to enable meaningful evaluation of the system by a group of USAF environmental planners. This end-user feedback is important for identifying features and capabilities that are most desired by members of the environmental planning community.

High-priority implementation items to achieve a realistic test system include:

- a model to produce continuous MTR noise exposure values so that meaningful computations can be performed for finite flight segments;
- MTR point of interest calculations;
- show intermediate results for MTR calculations;
- a (probabilistic) model for supersonic MOA operations;
- printed output for the citation database;
- initial effect calculations for structures;
- initial effect calculations for animals;
- land use compatibility calculations; and
- reporting capability.

Technical issues must also be addressed. The preliminary version was not very robust in its implementation. It demonstrated the tool, but with little provision for auditability or protection against user errors. The programs will have to be fortified so that they will stand up under a real-life use of the system during the user test.

Other technical issues have become apparent in the present effort, particularly the inherent limitations of the current hardware and software. The functional capabilities desired for ASAN have traditionally been performed on large-scale computers. Since the goal of the initial

development was to create a proof-of-concept system, it did not concern itself with the intricacies of squeezing these capabilities into a desktop computer.

The ASAN design specification also recognized that, because desktop computer technology is evolving at a rapid rate, periodic reevaluation of the software and hardware is required. This effort will require evaluation of the best current solutions to technical problems, as well as attention to long-term USAF strategy in computer procurement policies.

4.2 Alpha-Test User Evaluation

Once a functional prototype that addresses these issues has been developed, a group of USAF environmental planners will be invited to a hands-on evaluation of the prototype ASAN. This evaluation could be conducted on a one-on-one basis with an ASAN developer working with the planner and exploring the capabilities of the program, or in other ways.

The objectives are to explore the capabilities of ASAN from the point of view of the prospective user, and to solicit constructive feedback on the features and capabilities provided. An informal task analysis was conducted at the beginning of the effort described in this report. A more formal review of the software in the context of actual planning practice over a reasonable period of time is, however, most valuable.

4.3 Final Prototype

Features will be added or modified to reflect end-user input. ASAN's repertoire of capabilities will also be extended, to yield a larger, and possibly less sophisticated, user community access to ASAN.

Development of :he next version would be likely to include:

- more sophisticated MTR calculations based on the model expected to be published by Armstrong Aerospace Medical Research Laboratory (AAMRL) in the near future;
- supersonic MOA models developed in other tasks;
- structural effects modules that become available within this period;
- ability to import more or less "standard" machine readable data into ASAN, e.g., digital maps;

- expanded forward query capability, e.g., calculation of percent of population in an area affected by exposure;
- expanded backward query capability, e.g., given a point on the map, which activities contribute to the noise environment;
- graphic input/output tools identified in the user alpha-test; and
- interfacing or integration of a text preparation system to facilitate using ASAN output into formal USAF documents.

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